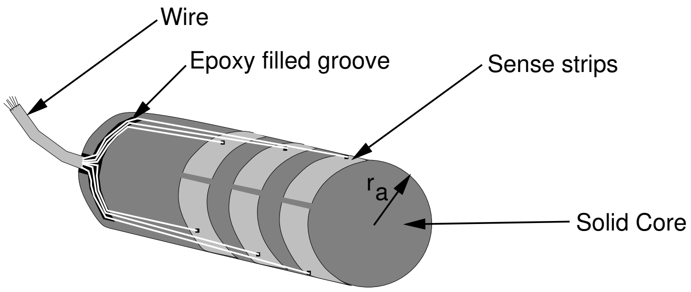


Figure 1: Finger core with wire channel.

Finger Construction Steps

E.J. Nicolson

In this procedure, "Upper mask" refers to a piece of copper which has been photomasked with the resist pattern for the upper electrodes and "lower mask" refers to the piece masked for the lower electrodes. Figure 1 shows the sensor core and sense strips with the groove (wire channel) for the 8 conductor wire.

1. Prepare core
   - (a) Choose radii r_a and r_b and sampling density.
   - (b) Cut stock to length (32 mm final, 35 mm rough), lathe to desired radius, face ends (speed above 200, 3.0 inches/min).
   - (c) Center drill, Drill # 7 hole, tap for 1/4-20 thread.
   - (d) Cut 1/4-20 threaded rod stock.
2. Prepare mask
   - (a) Paint nail polish onto back of mask.
   - (b) Cut out bottom portion, leave about 0.25" copper at the end, cut sides close. Length should be $< 2\pi r_a$.
3. Attach lower mask
   - (a) Glue mask to core using Devcon 5 minute epoxy. Be sure not to get any epoxy on front copper since it will act as a resist. This is most important in the sensing area, but not so important at

the ends. Sensing electrodes should be at the end opposite to the tapped end.

(b) Etch in Ferric Chloride. Add 25% hot (25 ml) (near boiling) water by volume to etching fluid to speed process. Swirl for about 20 minutes.

(c) Wash off in water. Let dry.

(d) Drill alignment hole. 1.6mm diameter $\simeq$ #52 approximately half way between center and outside. Err to the outside to leave enough room for the nut. The location is to the left side looking from the top with the front up. Drill Air escape holes , #29 drill, all the way through.

(e) Use the mill to cut channels for the wires. Turn on the monitor, turn on the mill power, turn on the air. Set up the vice with the pin in the third hole from the left. Insert the tool. Mount the sensor back facing up. Use manual control to find the approximate zero at 9in/min. Reduce the speed to 2in/min and take small z steps to find the correct height. Set the zero position from the Initialize menu. Load c:\ ed \ filename. Run. For new tool find new z origin.

When doing the front, mill a small cut in the center, front, and bottom end to use for alignment with center of the upper mask. Use the 0.025" tool. Be very careful since the tool breaks easily. To make the notch in the bottom end, jog .05" in x, .01" deeper in z each time at a speed of 1"/min.

Mill Programs, mount core with $x + ive$ = cylinder axis to top				
$r_a * 2$	Side	Program	Tool	Origin
22 mm	Back	BC1	5/32" flat end	center back, cable end
		BC2	1/16" flat end	center back, cable end
	Front	FC1	5/32" flat end	center front, cable end + 5/64"
19.5 mm	Back	FC1	5/32" flat end	center back, cable end
		BC2	1/16" flat end	center back, cable end
	Front	FC1	5/32" flat end	center front, cable end + 5/64"

(f) Repair strips by gluing with "superglue" any loose traces. Cut off any copper that was not properly etched.

    (g) Scratch off resist for wire connections at ends of traces. Tin these patches with a small amount of solder.
    (h) Use 8 conductor, 30 gauge, shielded, Cooner wire (part number AS148). Tin 8 wires. Glue the wire casing into the core wire channel and solder to traces using the color code
    (i) Test connections for shorts between traces and open circuits.
    (j) Fill wire channel with 5 minute epoxy to glue the cable in place and immobilize it.

4. Attach upper mask
    (a) Create dielectric.
        i. Use the machinable wax mold with 0.025” ball end holes at 0.040” spacing to a depth of 0.004”.
        ii. Mix HSII rubber using a ratio of 10:1 by weight of base to catalyst. Mix by mushing more than stirring to avoid introducing too much air into the mixture.
        iii. Smear enough on the mold to cover the holes, but not much extra.
        iv. Vacuum for 3-4 minutes until large bubbles start to form. Do not over vacuum.
        v. Press on a clear plexiglass cover and push hard around outside edges of the mold to ensure a thin layer.
        vi. Leave weights on top of the plexiglass for about 12 hours.

(b) Glue on the upper mask using Silicone glue. Glue the mask to the smooth (not bumpy) side of the dielectric. Use a healthy amount of glue. Trim to 1/4 inch on the ends, but as close as possible on the top and bottom ends. Let this dry.

(c) Etch as in 3b. Be gentle so that the copper does not separate from the dielectric.

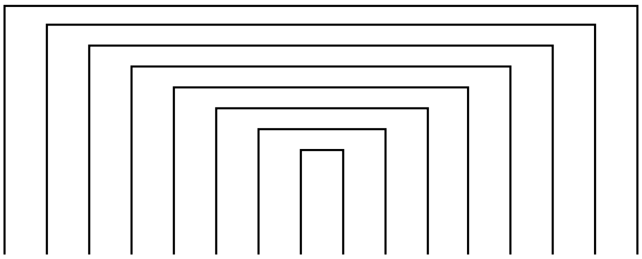
(d) Wash in clear water and let it dry.

5. Assemble upper mask on lower.

   (a) Glue upper mask to the core using Silicone glue. Use plenty around edges on both surfaces. In the sensing area put only a thin film on the core. (Be careful not to get glue on the copper areas between the traces.) Align center of upper mask to lower mask using the alignment notch. Let the glue dry.

   (b) Scrape off the resist on alternating upper traces near the corners. Looking at the front of the sensor with the cable end at the top, start with left side removing the resist and tinning carefully.

   (c) Tin another 8 conductor cable and super glue the cable cover to the wire channel. Use the following color code.



   (d) Create the shield by using a modified upper mask. Paint nail polish on the back and over connecting wires on the front including 1mm over the tops of the drive lines. This shorts all the electrodes together. Etch this as before. At this point the shield is very fragile as the only thing holding it together is the nail polish.

Glue the shield over the drive lines with a small separation given by the silicone glue. CUT the nail polish between strips when the glue is dry.

(e) Make a copper circle for the end and glue it with epoxy or superglue. Connect it to the shield of upper (drive) cable. This will be grounded.

(f) Fill the wire channel AND the space between connecting wires up to sensing area with 5 minute epoxy. These connecting wires must be immobilized. Let the glue harden.

(g) Solder the cable to an 18 pin header with the following color code.

Pin	Sense Color	Pin	Driver Color
1	White	18	Yellow
2	Green	17	Black
3	Blue	16	White
4	Brown	15	Blue
5	Black	14	Brown
6	Red	13	Green
7		12	Red
8		11	Orange
9	Shield	10	Shield

(h) Test wiring. Check for shorts between all combinations of connector pins. Check that it works when plugged into the circuit. Check that all connections are good.

(i) Screw in a 1/4-20 shaft.

(j) Smear the finger mold with vaseline and warm it with a heat gun. Blow off the excess vaseline with compressed air. Place the finger in the mold. Tighten the end against the bottom of mold for axis alignment. Check that there is equal space on the sides and the front and back.

(k) Close up the mold. Tape down the reservoir ring with electrical tape. Seal the top with tape so that air must be replaced by rubber in the vacuum. Insert alignment pin!

(l) Mix 20g HSII base with 1/10 catalyst by weight. Smash, don't stir.

(m) Pour into the mold. Vacuum 2-3 minutes until large bubbles START to form. Remove. Fill reservoir again. Vacuum in cycles of 2-3 min on, 1 min off for 15 minutes. Don't let it "boil".

(n) Let it sit 1 day.

(o) Remove pin. Remove from mold, insert pin.